

Assessment of CFSv2 forecasts of parameters associated with U.S. monthly tornado activity

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Is it time to consider extended range,
monthly or seasonal forecasts of
tornado activity?

No

- Observations are bad
 - Tornado data is unreliable. Data quality and uncertainty will affect results. Should first work to improve the tornado dataset.
- Numerical models are bad
 - Model have biases in the Central US. Warm season precipitation is poorly represented. Varying bias patterns in tornado-prone regions.
- Forecasts are bad
 - Extending any results based on reanalysis and observations to forecasts is problematic. Forecast biases in the central US.

A hard problem to ignore

- April and May 2011
 - \$22.5 billion total losses
 - 540 fatalities
- March 2012
 - First billion-dollar weather disaster of 2012
- “You go to war with the army you have, not the army you might want or wish to have at a later time.”

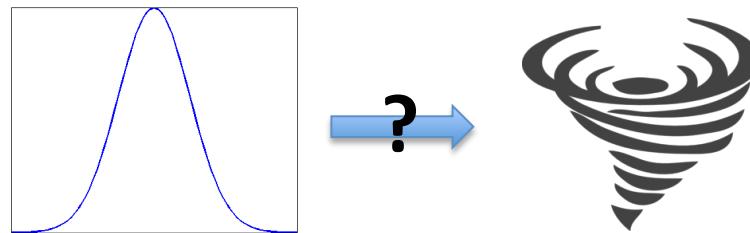
Outline

- Background
- A new monthly tornado activity index
- “Perfect prognosis”
- Monthly CFSv2
 - Climatology
 - Forecasts

Basic Questions

1. Can environmental parameters explain tornado activity?

Does the distribution of environmental parameters during a month determine tornado activity?



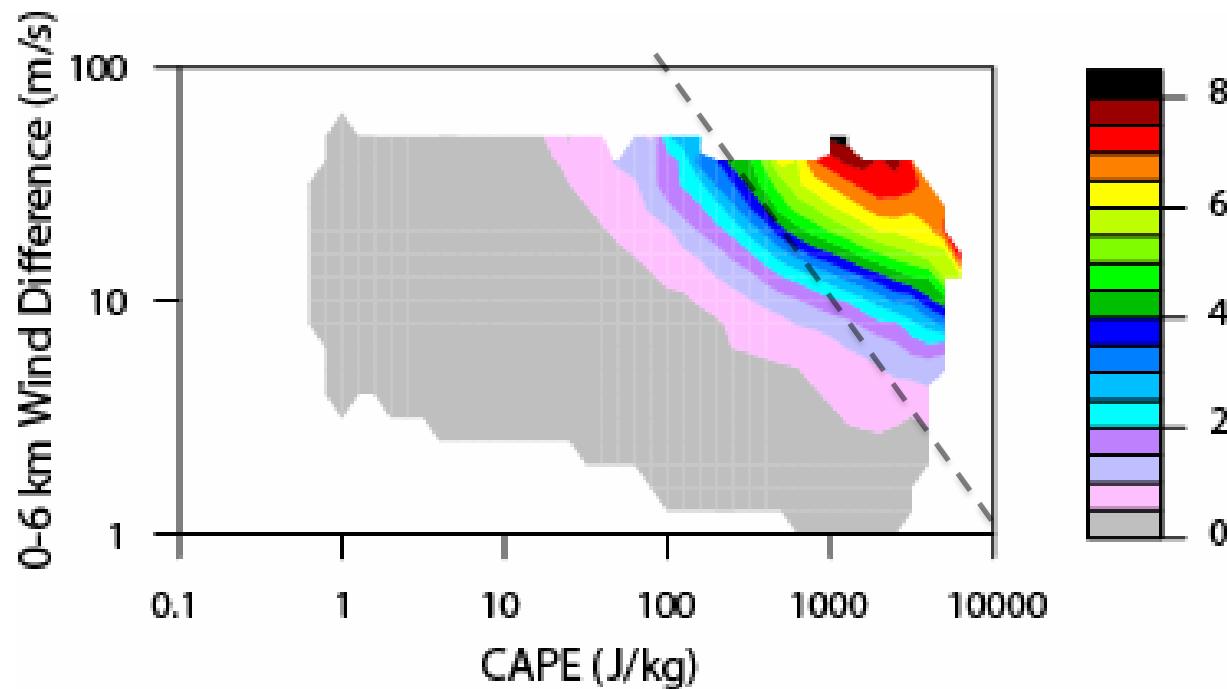
2. Is there information in monthly environmental parameters which is associated with monthly tornado activity?
3. Are they predictable?

Background

Typical environmental parameters associated with tornadoes

- Instability, updrafts, e.g. CAPE
- Shear, e.g., 0-6km shear, Storm Relative Helicity (SRH)

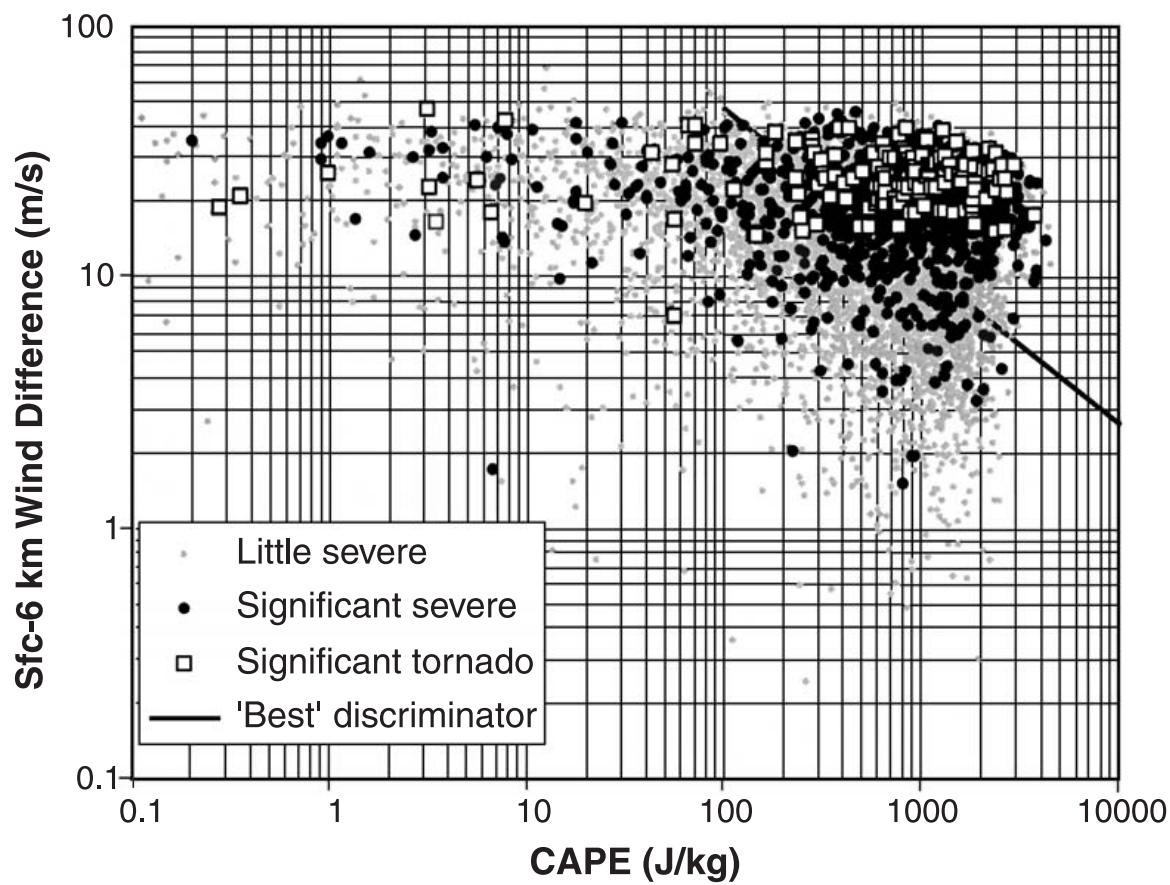
Probability of severe thunderstorms with F2 tornado, 5cm hail, or 120 km/h wind gusts



Soundings in the vicinity of severe thunderstorms

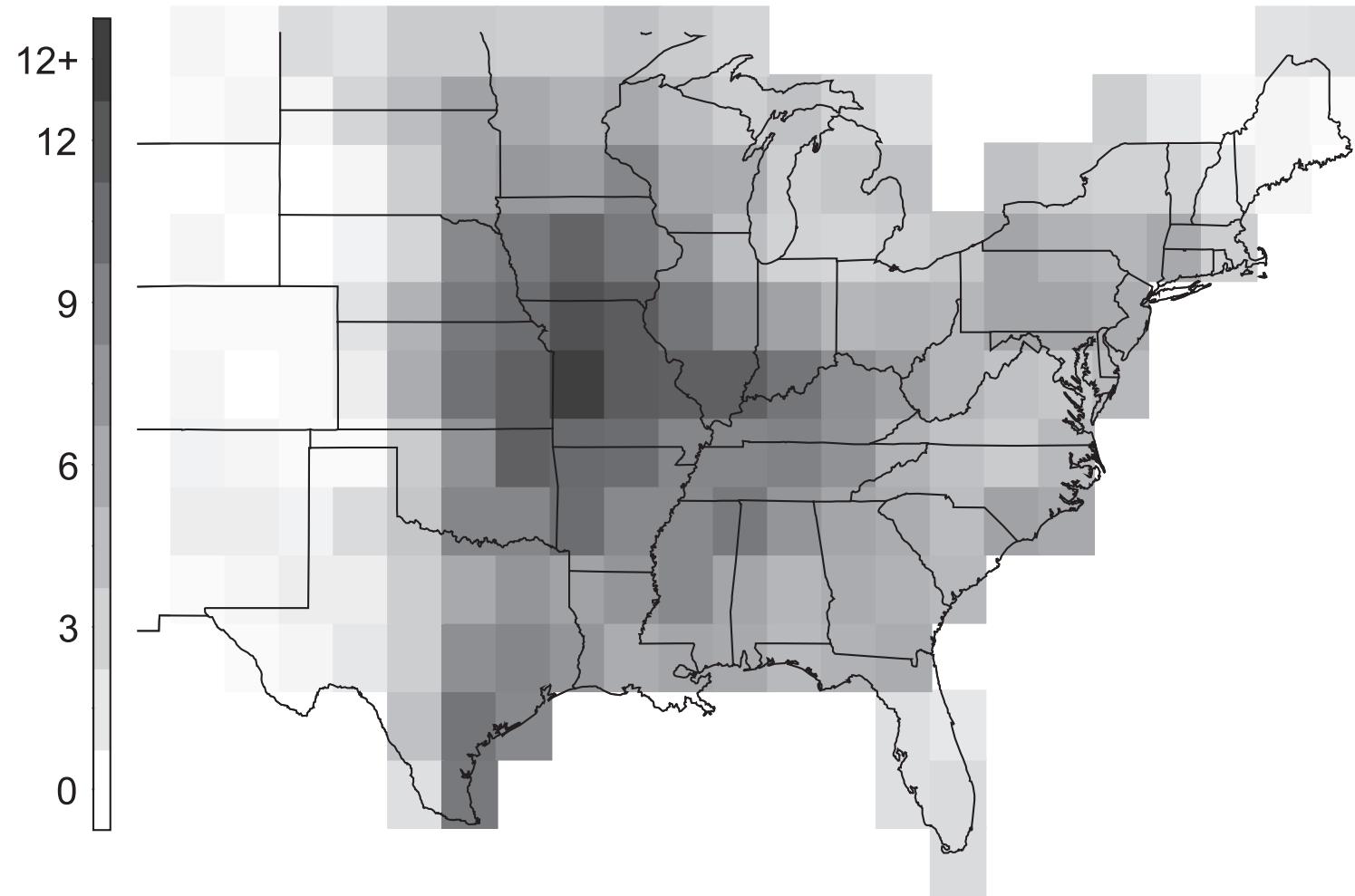
Significant severe parameter (Craven and Brooks, 2004)
CAPE \times 0-6 km Shear $> 10,000 \text{ m}^3 \text{s}^{-3}$
Figure from Brooks and Dotzek (2008)

NCEP/NCAR 6-h reanalysis environmental parameters near severe thunderstorms 1997-1999



(Brooks et al. 2003)

Days per Year with Favorable Tornado Parameters



6-hourly reanalysis

(Brooks et al 2003)

A new monthly tornado activity index

A monthly index for the number of U.S. tornadoes

- Index = $\exp(\text{constants} \times \text{environmental parameters})$
- Constants estimated by Poisson regression
- Potential parameters = CAPE, CIN, lifted index, lapse rate, mixing ratio, SRH, vertical shear, precipitation, convective precipitation and elevation
- Estimate constants from observed climatology
 - Avoids issues with changing technology and reporting practice
 - Same constants at all (U.S.) locations, all months of year
- Data
 - NARR data 1x1 degree grid. 1979-2010.
 - SPC Tornado, Hail, and Wind Database. 1979-2010.
 - All tornadoes (>F0). [F1 and greater gives smaller values, similar sensitivities]

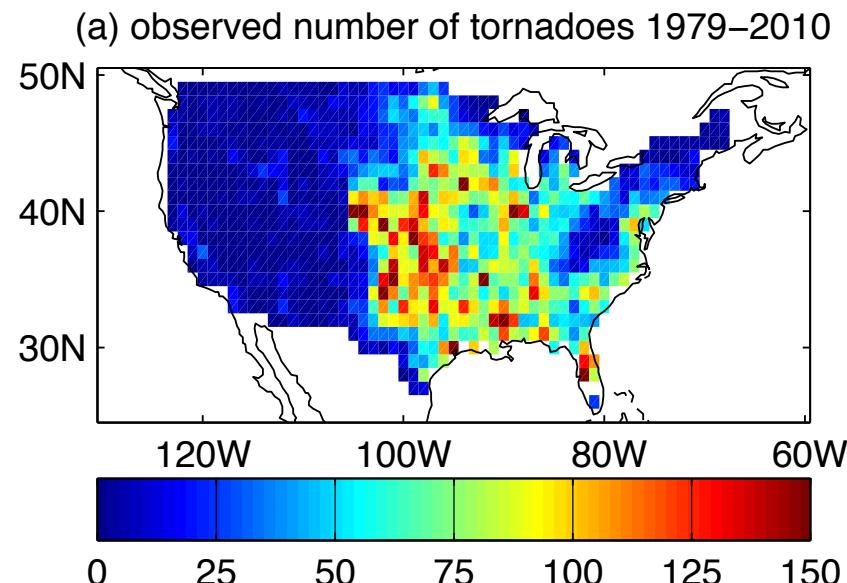
A monthly index for the number of U.S. tornadoes

- Parameters = SRH and convective precipitation
- Estimate 3 constants from annual cycle data
 - No annually varying data used to select parameters or fit constants
 - No forecast data used. “Perfect prognosis”
- Index = Expected number of tornadoes/month
 - 1x1 degree grid
 - All tornadoes (>F0).

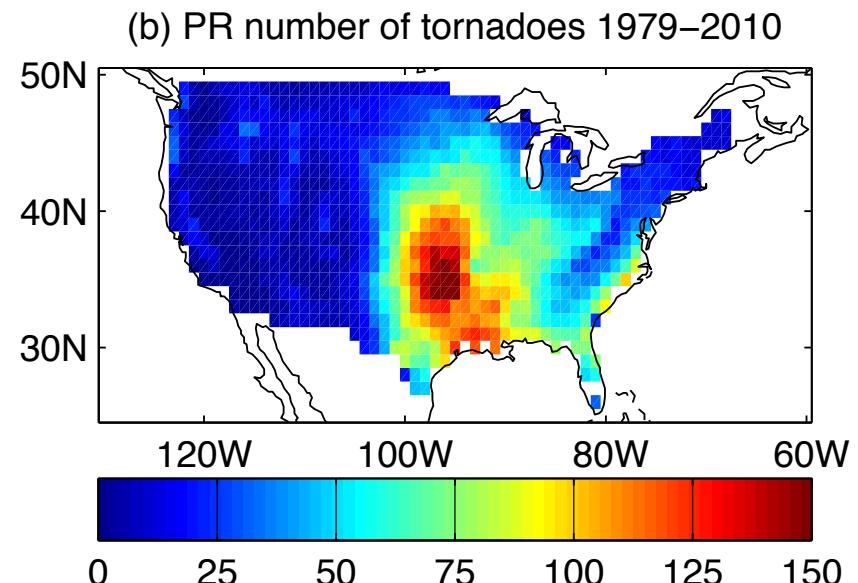
Perfect prognosis results with NARR
environmental parameters

Climatology

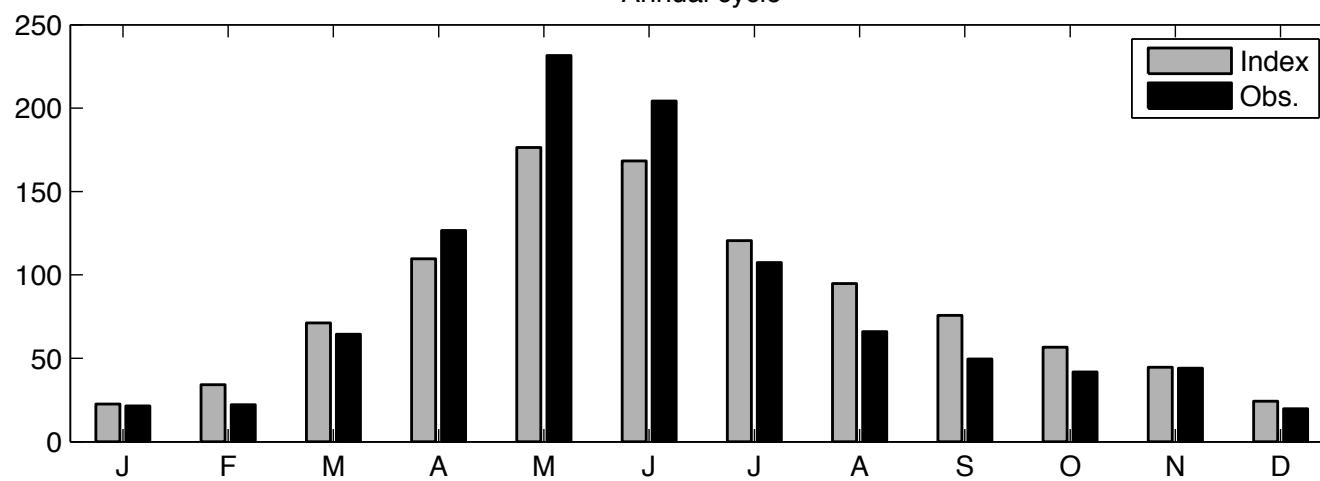
Observations



Index



Annual cycle



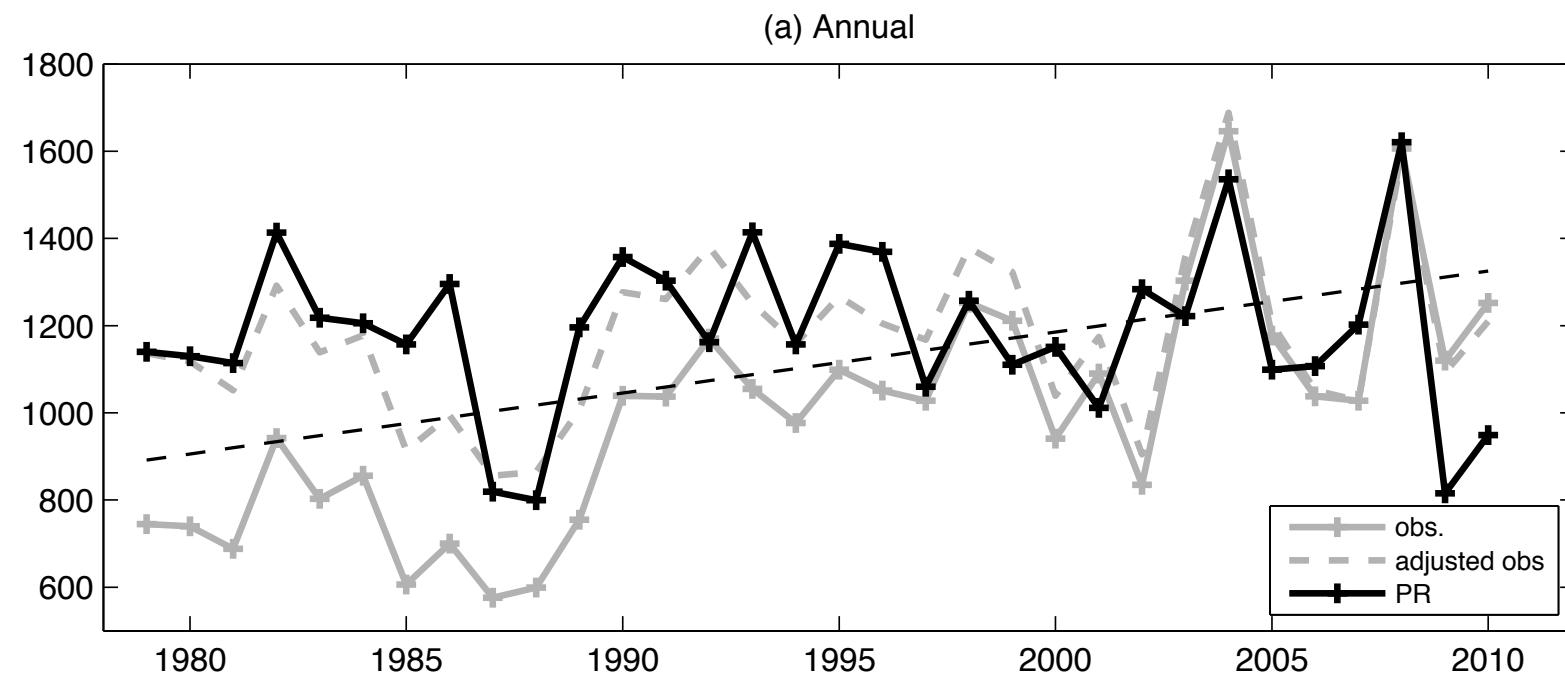
Annual cycle



Interannual variability

Correlation between index and observed number CONUS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.75	0.64	0.54	0.50	0.60	0.67	0.75	0.40	0.15	0.25	0.48	0.74



(b) April

Interannual variability

What is the relative importance of the factors?

Correlation between index and observed number CONUS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Index	0.75	0.64	0.54	0.50	0.60	0.67	0.75	0.40	0.15	0.25	0.48	0.74
SRH only	0.24	0.12	0.14	0.34	0.41	0.39	0.51	0.31	-0.16	0.13	0.21	0.37
cPrcp only	0.76	0.58	0.68	0.60	0.30	0.54	0.60	0.33	0.15	0.28	0.53	0.74

Most months, cPrcp variability is more important

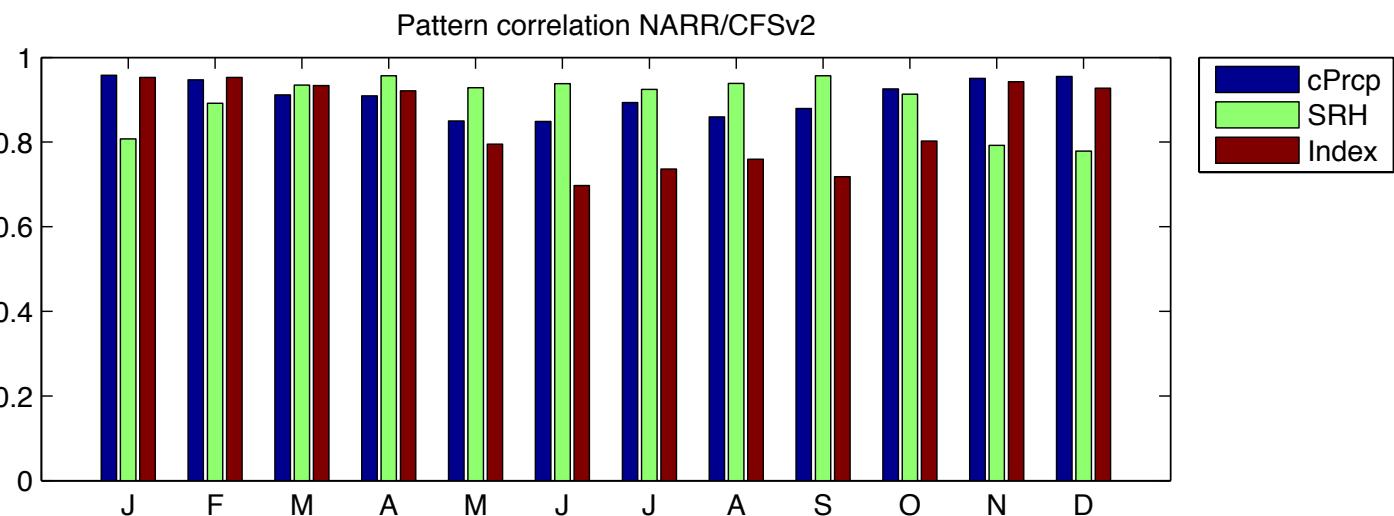
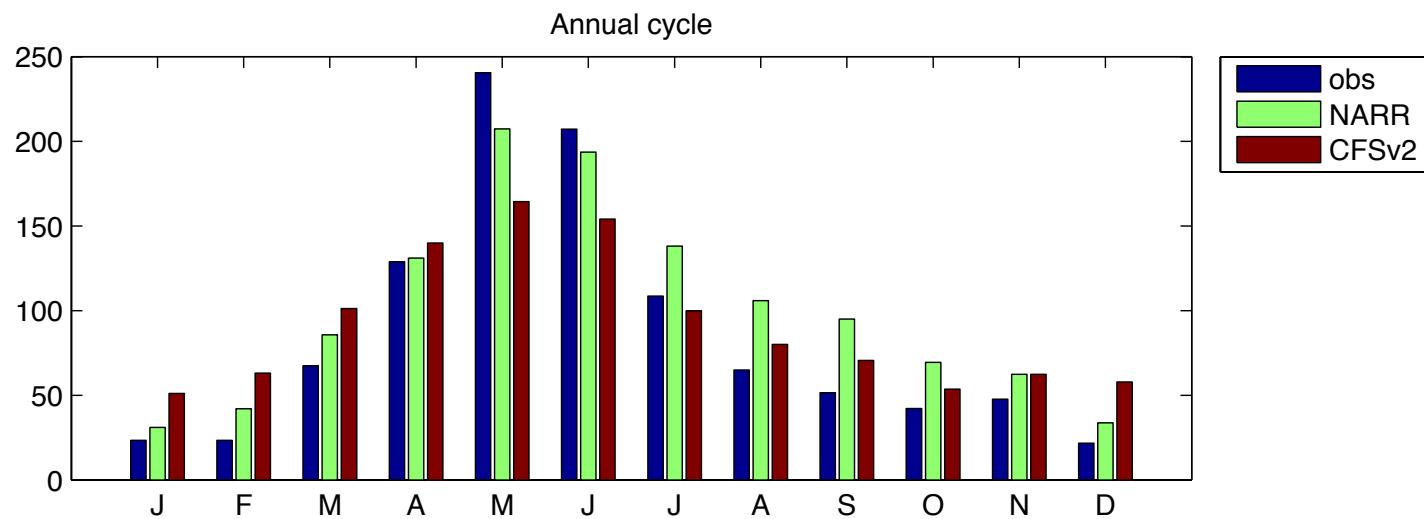
Monthly CFSv2 forecasts

CFSv2 hindcasts

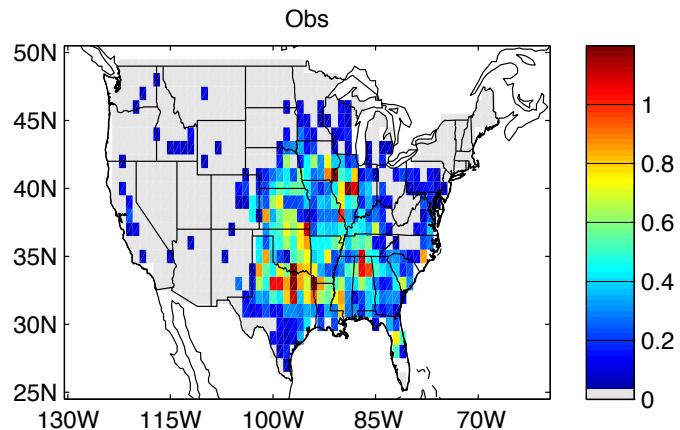
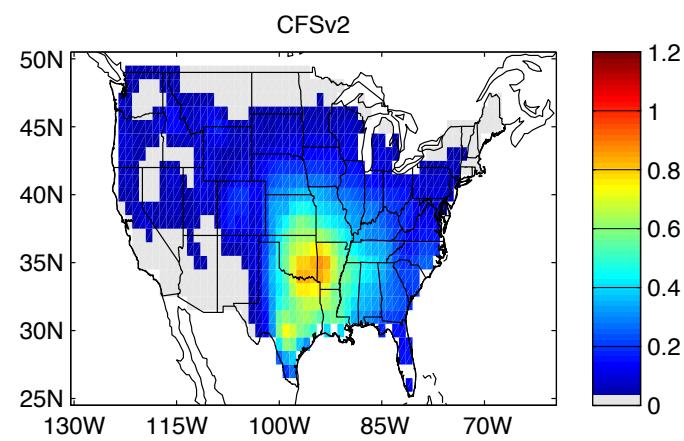
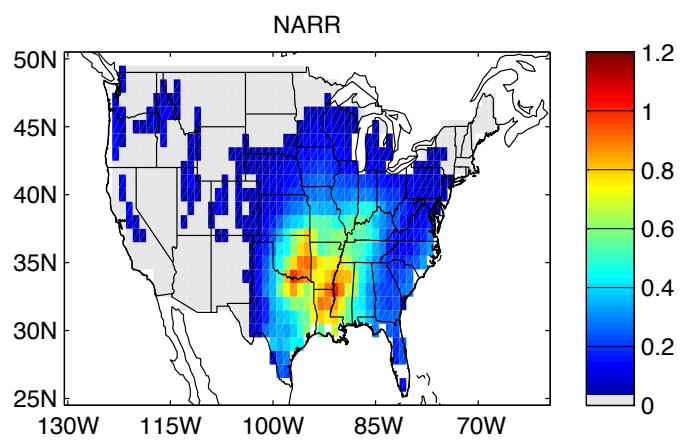
- 1982-2010
- First month lead
- 16 ensemble members (9-24)
- Forecast June average = start from May 21,
May 26, May 31 and June 5
- Same index constants (no MOS)

Climatology

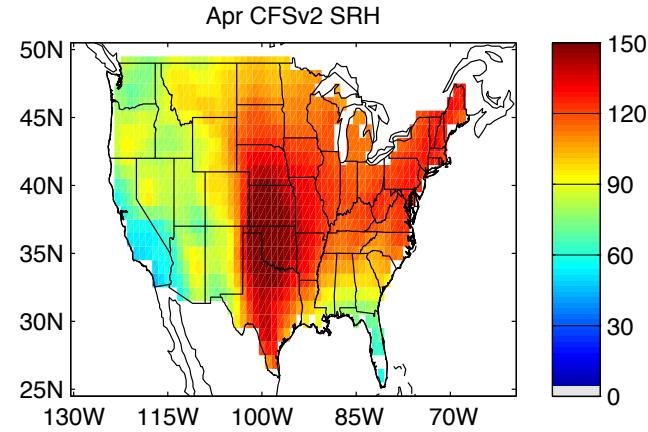
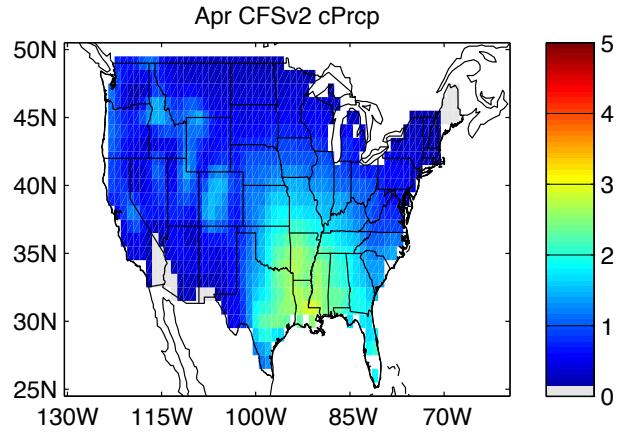
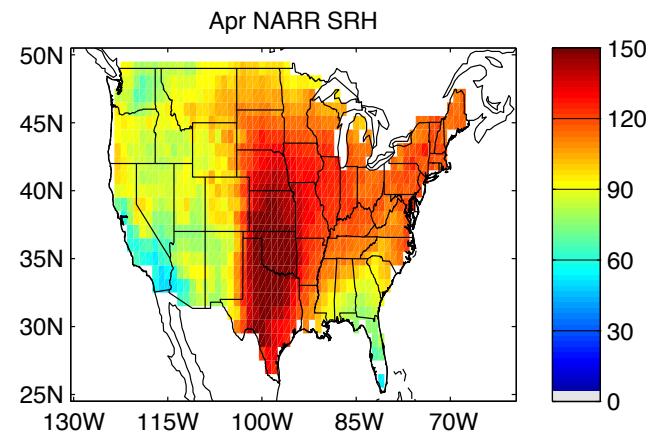
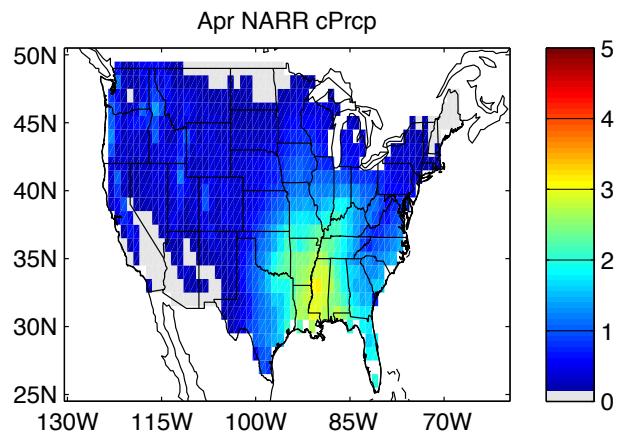
Climatology



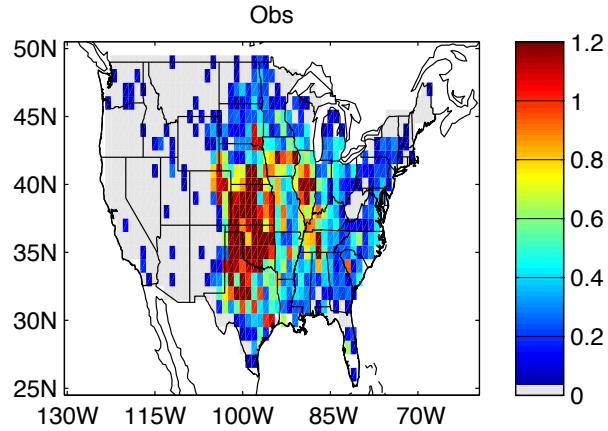
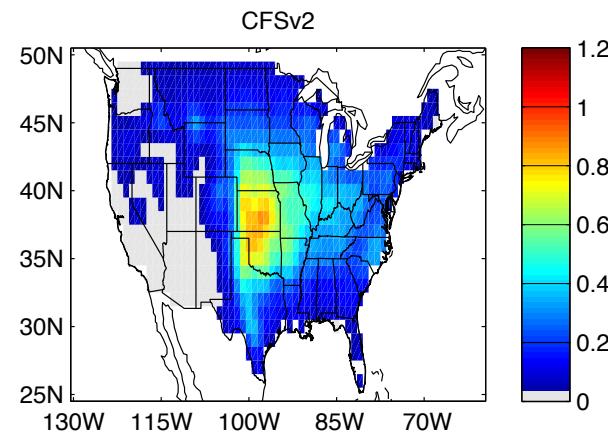
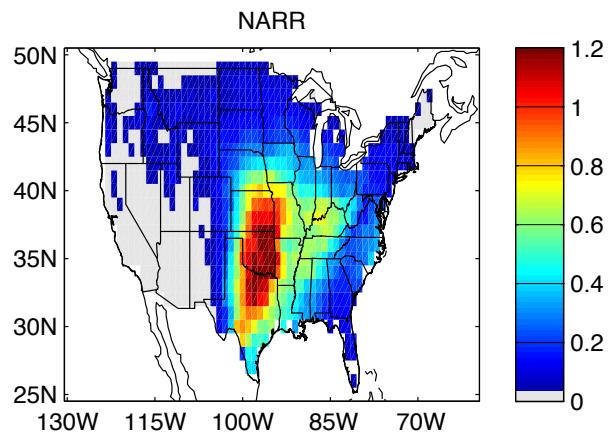
April indices



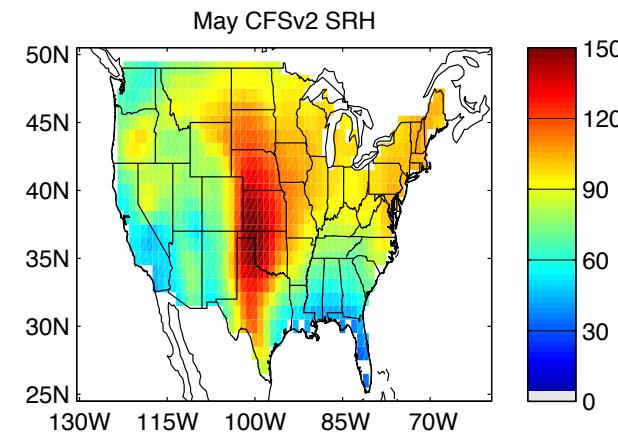
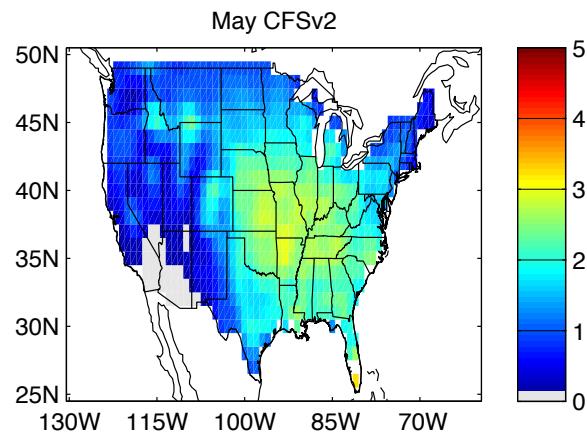
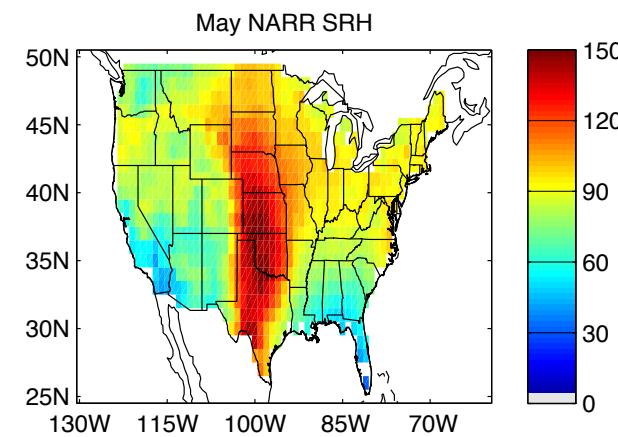
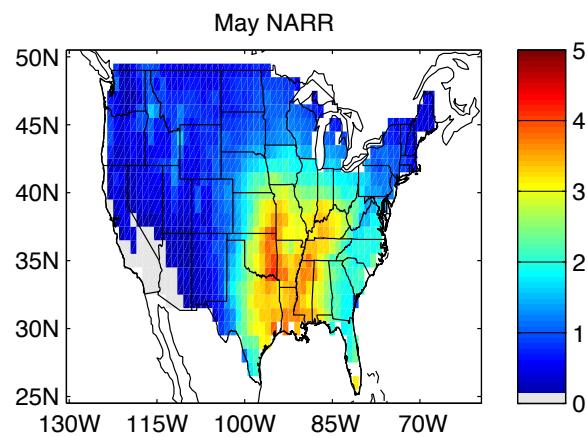
April parameters



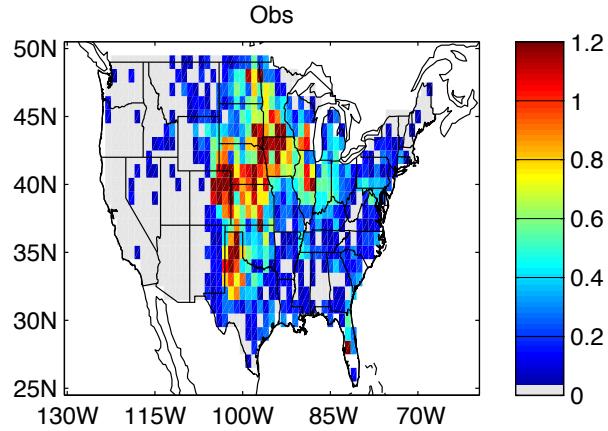
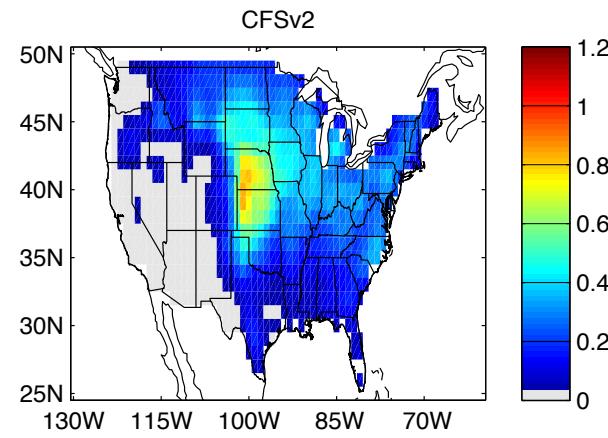
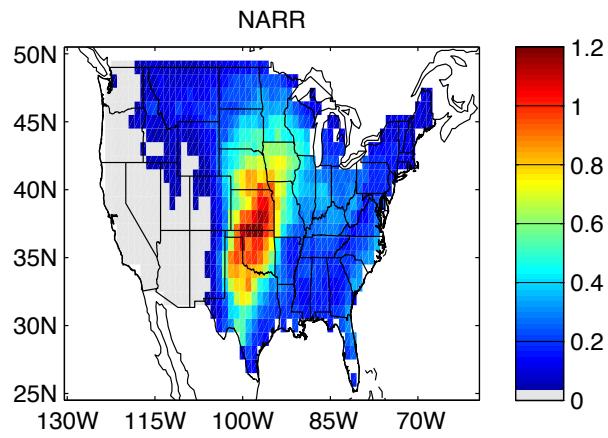
May indices



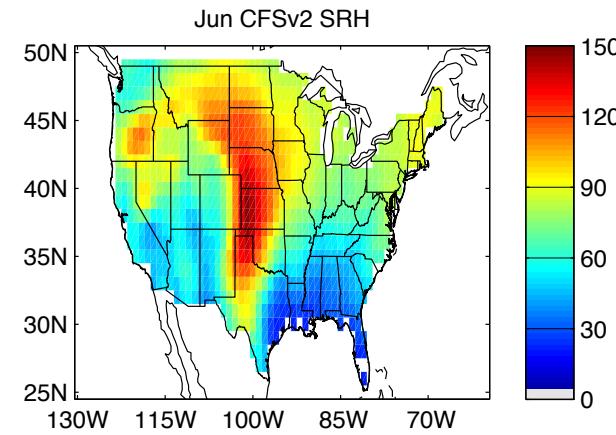
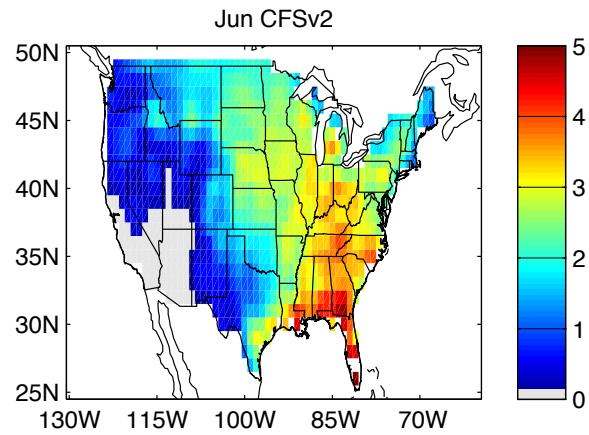
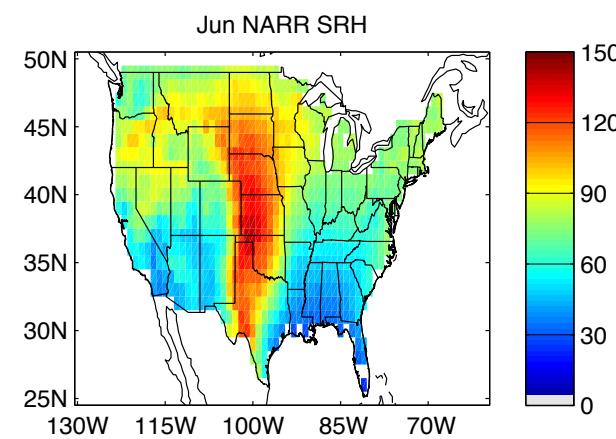
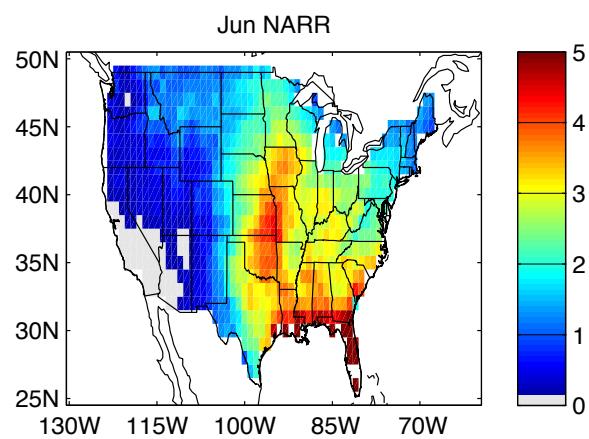
May parameters



June indices



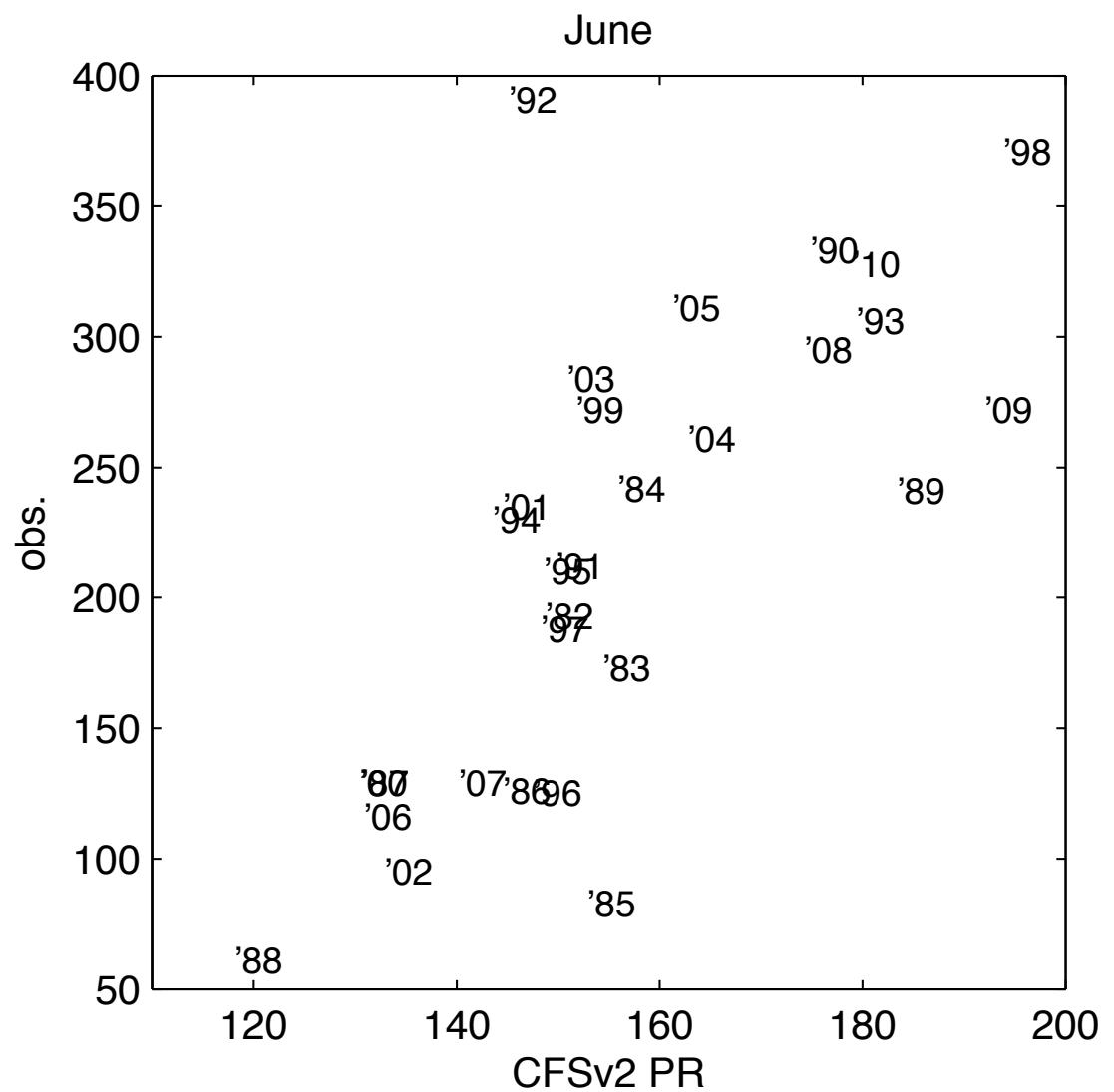
June parameters



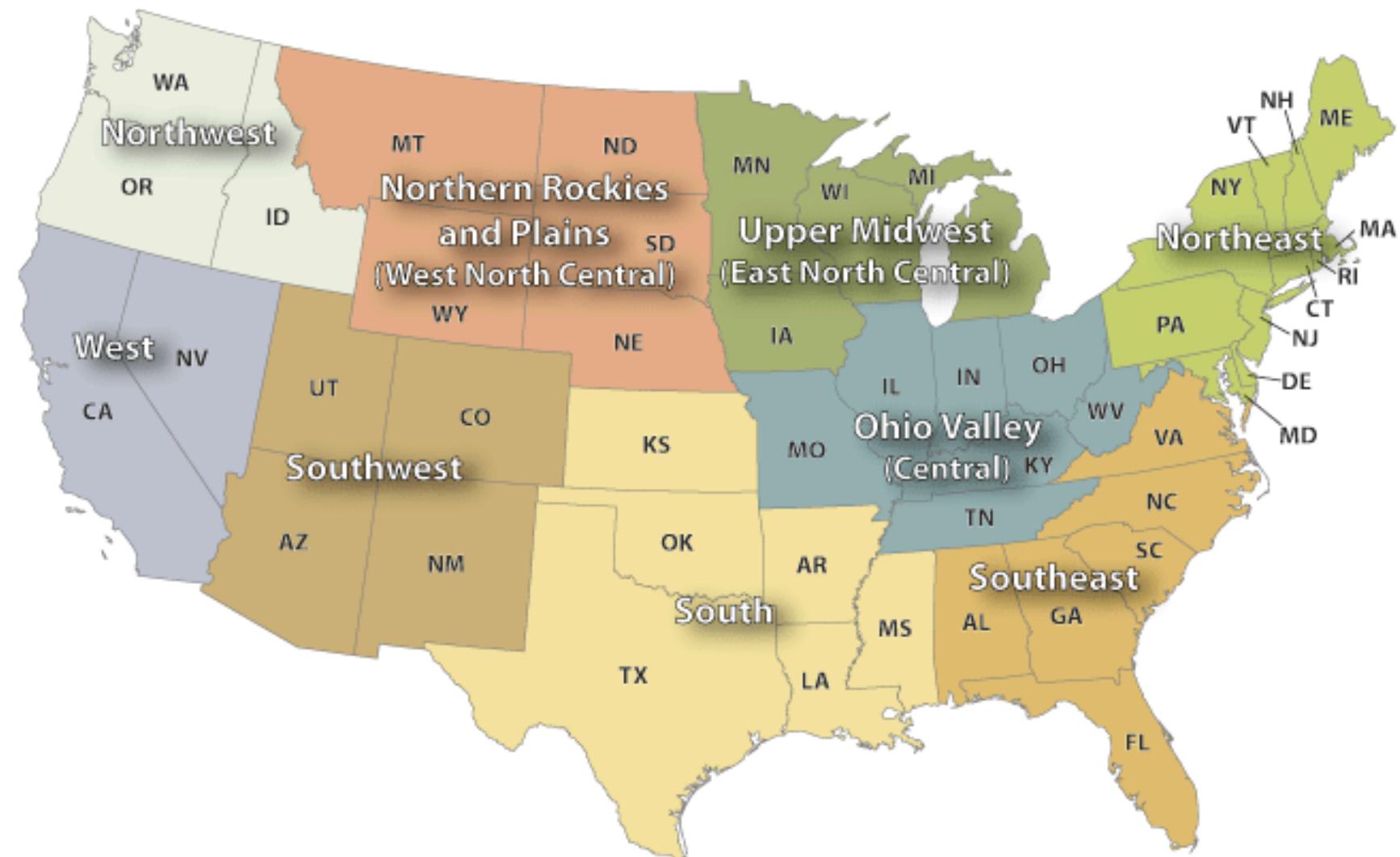
Monthly Forecasts

Correlation between index and observed number CONUS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NARR	0.75	0.64	0.54	0.50	0.60	0.67	0.75	0.40	0.15	0.25	0.48	0.74
CFSv2	0.36	0.38	0.30	0.35	0.31	0.72	0.59	0.41	-0.25	0.18	0.41	0.37



U.S. Climate Regions



Regional correlations

Summary

- A new index associating environmental variables and US tornado activity
 - Explains aspects of annual cycle and interannual variability
- Systematic differences between NARR and CFSv2 convective precipitation.
- Monthly CFSv2 forecasts of index show some skill on continental and regional scales
- MOS could be beneficial